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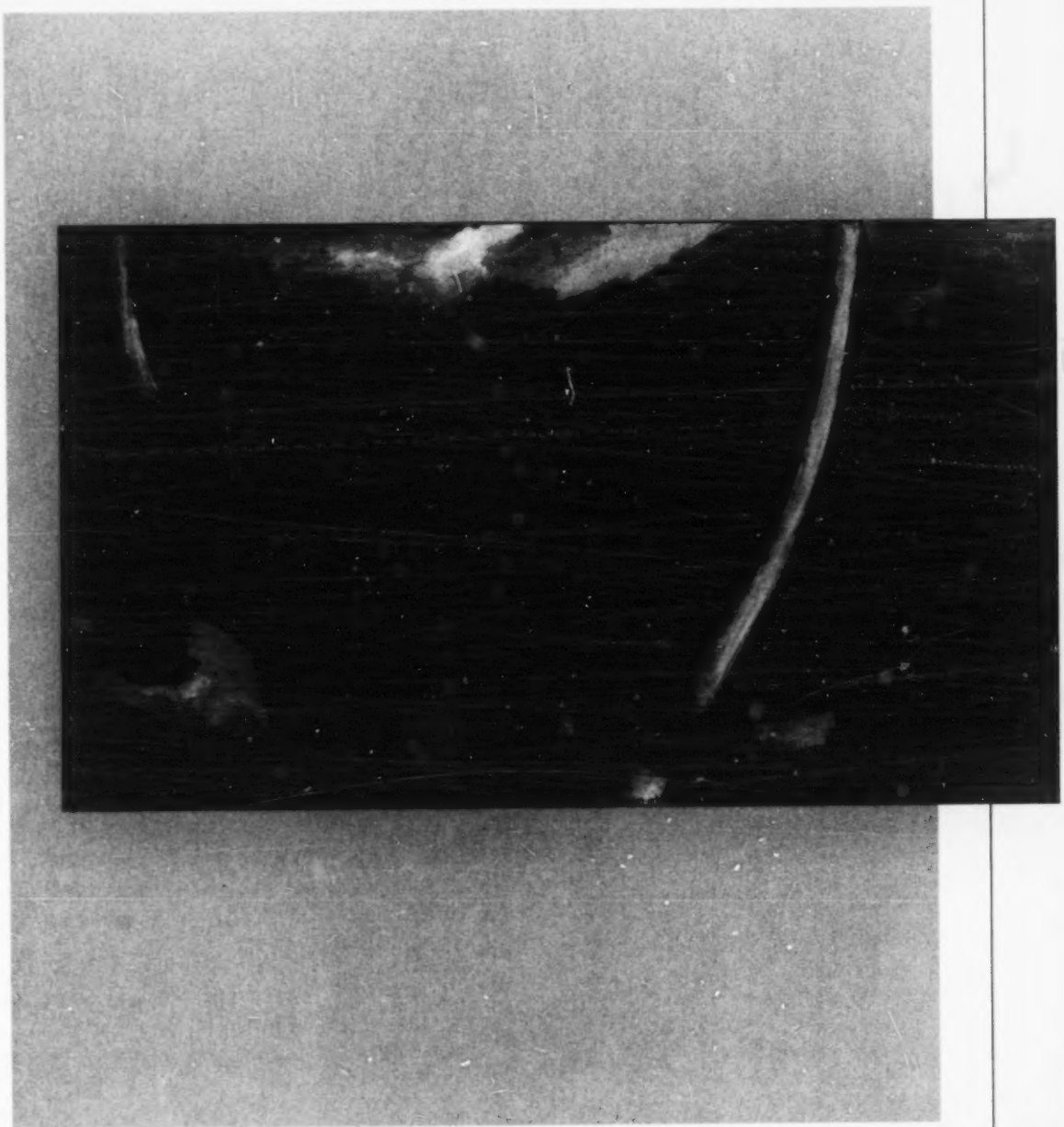

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BPA

Professional burnout among female veterinarians in the United States

A. D. Elkins, DVM, MS, and Michael Kearney, MS, MA

Dr. Susan G. practices veterinary medicine in Atlanta, Ga in a busy small animal hospital with two male colleagues. She is married to an accountant and has a four-year-old son. She has been with the same practice since she graduated from veterinary school 6 years ago. Susan dreamed of being a veterinarian since the age of twelve. As a youngster she loved animals and owned a horse. Her father, a hard-driving successful dentist, encouraged her to pursue a career in the medical field. Susan was an ideal student in veterinary school and graduated in the top 5% of her class. She maintained these same high standards as she began her practice career. Susan quickly discovered that women in her graduating class were offered $2,000 to $4,000 less per year than their male counterparts. She continued to experience this financial discrimination in her current position. Susan had begun to feel the pressures of working 40 to 45 hours per week as a veterinarian and being a full-time mother and wife.

Susan is a good veterinarian with high professional standards. Everyone agrees that her goals are worthy and admires her for maintaining the dual role of professional and mother/wife. To all appearances, Susan is a 20th-century success story. However, Susan is on the brink of professional burnout.

Burnout is best described as a state of emotional exhaustion, in which work becomes routine and mechanical. Burnout is often accompanied by feelings of disenchantment toward work and hostility toward clients and their problems. It is accompanied by feelings of anger expressed in a negative, cynical attitude toward others, particularly clients. Clients are objectified and treated as subjects or cases rather than people.

Burnout syndrome can be identified with four Ds: disengagement, distancing, dulling, and deadness.[1] The burned-out individual may change positions or jobs, continue to work in a robot-like fashion, or discontinue work completely.

Our society exerts pressure on women to assume family responsibilities, such as child rearing, which may influence the rate at which they experience burnout. Studies have shown that female physicians have higher negative responses to the conflicting roles of family and professional responsibilities than do male physicians.[1] The decision for a woman to enter a "man's profession," such as veterinary medicine has only recently become socially acceptable. Because of a rapid gender shift from 1971 to 1987, 22% of the total number of veterinarians in 1990 were women. In 23 colleges of veterinary medicine for 1988 to 1989, 57% of the veterinary students were women.[2]

The purpose of the study reported here was to determine the stress and burnout level of female veterinarians throughout the United States. An attempt was made to draw various comparisons between this survey and a similar survey that was completed in 1981 with 95% of the respondents being male veterinarians.

Background

The exact causes and sources of burnout are unknown, although social psychologist, Dr. Christina Maslach,[1-5] and psychoanalyst, Dr. Herbert Freundenberger,[6-8] through research and clinical work, respectively, are beginning to outline the essential features of burnout. Burnout can be traced to self-images formed in early childhood.[6] During those early years, one has a variety of psychological needs that are satisfied when that person adopts certain forms of behavior. Children receive psychological support for being "the little helper," "the rescuer," "a big little man," "the smart one," or "good." One or more of these roles and the self-images associated with them become the foundation for the hard working, competent, dedicated and idealistic professional person.

Professionals become prime candidates for

From the Indiana Veterinary Surgical Referral Service, 8250 Bash St, Indianapolis, IN 46250 (Elkins), and the Department of Epidemiology and Community Health, College of Veterinary Medicine, Louisiana State University, Baton Rouge, LA 70803 (Kearney).

burnout if their idealistic, competent, vague (and perhaps perfectionistic) self-images conflict with other parts of themselves that have been suppressed over the years. There is a strong possibility that students cut themselves off from many of their feelings to realize their goal of becoming highly professional veterinarians. Many female veterinarians feel the pressure of being full-time professionals while wanting to spend more time with their families. One may become a victim of burnout if the disparity between self-image and inner self is great enough.

The childhood foundation for burnout is reinforced in the educational process. Extensive professional training results in a series of short-term gratifications followed by long-term deprivations. The graduating college senior feels great that she has accomplished a goal, only to become a freshman veterinary student. Upon graduation as a veterinarian, she begins her first position of employment and again finds herself at the bottom of the heap. At this time, she is faced with the realities of professional responsibilities and the world of economics. By diligent work, young professionals adapt and begin to cultivate successful practices. However, the stress and pressures of constantly dealing with clients, colleagues, and staff begin to take their toll, and signs of burnout may appear. The personality traits that characterize a good professional are also traits that predispose people to burnout. These traits include control of emotional expressions, exacting attention to detail, conscientiousness, and prolonged deferral of gratification.[2] Extensive work has been done on the response of women physicians to the conflicting dual roles of family and profession,[9-11] but to our knowledge, nothing has been published on female veterinarians.

Table 1—Demographic characteristics of the respondents

Characteristic	Percent
Race or ethnicity	
White	96.7
Black	1.3
Asian	0.6
Hispanic	0.6
Other	0.8
Marital status	
Married	57.5
Single	33.0
Divorced or separated	9.5
Age	
30 and younger	24.4
31 to 35	41.8
36 to 40	23.4
41 to 45	6.6
46 and older	3.8
Number of children	
0	66.8
1	13.2
2	14.5
3	3.7
4 or more	1.8
Number of job changes since graduation	
No job change	25.0
1	21.8
2	18.7
3	18.3
4	9.4
5 or more	6.8
Current type of job position	
Small animal	63.0
Small animal/large animal	13.9
Large animal	5.3
Academia	8.4
Industry	3.1
Government (military, state, federal)	4.7
Not working	0.9
Working but outside veterinary medicine	0.7
Average number of hours worked per week	
20 or less	5.4
21 to 30	6.9
31 to 40	19.2
41 to 50	35.9
51 to 60	23.6
61 or more	9.0

Survey of burnout in female veterinarians

A questionnaire designed as an instrument for self-diagnosis of burnout, along with a letter of explanation, was mailed to 1,000 female veterinarians in the United States. These veterinarians were selected at random from the AVMA mailing list by region of the country. The subjects were asked to provide information about their work habits and other information that might be correlated to burnout. They were also asked to complete a burnout self-diagnosis instrument devised by Pines[4] (Appendix). All scores were confirmed by computer calculation. The extent of burnout was determined by use of Pines and Maslach's self-diagnosis scale.[4]

The data was analyzed by use of the SAS statistical package.[a] The analyses were performed by defined geographic region and results were combined over all regions. In all cases of inferential tests of hypothesis, the dependent variable consisted of burnout score, and independent variables included other elements in the survey instrument that were hypothesized to affect burnout score. In an attempt to remove the source of variation attributed to year of graduation, this variable was included as a covariate in the analyses of variance. All tests were considered significant at a probability level of $P < 0.05$.

The burnout scale yields scores of 1 to 7. A score of 1 to 2 indicates low levels of stress and dissatisfaction with work; a score of 2 to 3 indicates that the respondent generally feels good about herself with acceptable levels of stress and a manageable level of work dissatisfaction; a score of 3 to 4 indicates the beginnings of the burnout syndrome and the need to reexamine work and life priorities; a score of 4 to 5 indicates a state of clinical burnout and changes in work and life-style are imminent; a score of 5 to 6 is approaching a level of burnout where professional counseling is needed, and a score of 6 to 7 indicates severe burnout and

[a]Base SAS software, SAS Institute, Cary, NC.

the probable impairment of professional performance.

Results

A total of 613 (61%) female veterinarians responded to the survey. Five hundred seventy-two of the questionnaires returned were complete enough to be included in the study (Table 1).

Geographic regional effect was not revealed by any of the analyses performed. Correlation analysis indicated significant correlations between burnout score and happiness level, equal treatment, and choice of veterinary profession, which were all negatively correlated ($r = -0.55, -0.22, -0.33$, respectively), and between burnout score and hours per week ($r = 0.146$) and stress ($r = 0.38$). These results were further corroborated in the stepwise regression analysis wherein the best four-variable predictive model consisted of happiness, stress, choice, and hours per week, listed in order of decreasing importance in the model ($R^2 = 0.44$). Analysis of variance indicated that being a practice owner was the only significant variable affecting mean burnout score, in that owners recorded significantly lower scores than nonowners.

The average age of the women responding to the survey was 34 years. Fifty-eight percent of the respondents were married, and 67% had no children. Ninety percent graduated after 1970, with a mean graduation date of 1984. Twenty-one percent of the women had acquired board certification or formal training following veterinary school.

Eighty-two percent of the women were in practice; 63% were in exclusively small animal practices. Of the women in practice, 22% were owners of a one-veterinarian practice, 9% owned a multiple veterinarian practice, 12% were in a partnership, and 57% were employees of other veterinarians. Fifty-four percent had changed jobs 2 or more times since graduation, with a mean of 1.9 job changes. Sixty-nine percent worked 40 hours or more per week, with a mean of 47 hours per week. Seventy-six percent of the practices had 3 or fewer veterinarians with a mean of 2.9 veterinarians.

The women were asked to rate their response to four statements, using the Likert scale, with ratings 0 to 5, where 0 = no opinion, 1 = strong disagreement, and 5 = strong agreement, with 2, 3, 4 falling between strong disagreement and strong agreement. The four statements were:

1) I am happy in my current position!
2) Women are treated equally to men in the veterinary profession!
3) If I had the choice to make again I would choose the veterinary profession!
4) I consider my position stressful!

Eighty-three percent, 71%, and 87% scored 3 or above on the scale indicating they agreed or strongly agreed with statements 1, 3, and 4, respectively. Eighty percent scored 3 or below on the scale, indicating they disagreed or strongly disagreed with statement 2.

The respondents ranked potential stressors in practice from 1 to 6, with 1 being the most stressful, and 6 being the least stressful. Managing the practice was ranked as the number 1 stressor, economic concerns ranked as number 2, client relations as number 3, lay staff relationships as number 4, professional relationships as number 5, and personal/family relationships as number 6.

The mean burnout score of the 572 women respondents was 3.41 (range, 1.81 to 6.14). There was no difference in burnout score from the five geographic regions. The distribution of the burnout scores and percentage of respondents were as follows: 3% scored 1 to 2; 29.8% scored 2 to 3; 43.1% scored 3 to 4; 21.5% scored 4 to 5, and 2.6% scored >5.

Discussion

Many articles have been written in human medicine as to the effects of stress on female physicians.[9-11] Most psychologists agree that ability to cope with stress relates to personality type and childhood experience. For most people, the development of personality values and the crystallizing of life choices begins early in childhood. Girls in our culture are usually encouraged to choose more passive types of activities because these are considered to be more feminine and more consistent with their later roles. Scientific pursuits in particular are frowned on and considered to be masculine because of their association with assertiveness, precision, and responsibility. In the process of growing up, girls find that they need to deny aggressive traits even when they are actually functioning in areas in which these skills are necessary. There are blatant inconsistencies between the passivity and compliance expected of women in relation to men, and the activity and authoritativeness expected in the role of wife and mother.

A girl who is interested in medicine and who comes from a conventionally structured middle-class family may face conflict between her identification with her mother and her interests in a different pattern of life. If her relationship with her mother is close and relatively unconflicted, she may have difficulty because she may see herself as betraying her mother and competing with her to achieve more. If a woman has had a troubled relationship with her mother, she may become uncomfortable in seeking a demanding career because this interest may seem connected with the problems in the relationship as opposed to being a true career interest. A girl's identification with her father's professional role may promise an easier pathway for the development of her own serious career interests, but it may interfere with her rela-

tionship with her mother and with the resolution of identity issues. A man may have analogous conflicts, but more external supports are available to him to facilitate the resolution of problems of career choice.[11]

The structure of the medical profession has traditionally been organized by men who devoted their prime years to academic achievement or to building successful practices. Meanwhile, many of their wives stayed home managing children and household responsibilities. There are exceptions to this where the wife has built a career or a female physician has maintained a dual role of wife/mother and professional. Traditional role models pressure women to bear the burden of child care and perform most of the household chores. This social pressure, in addition to the professional career structure of medicine, make it extremely difficult for a woman to maintain multiple roles of wife, mother, and veterinarian. The period of intense career building coincides with a woman's peak biologic childbearing years. Therefore, to expect that women's careers should follow the same course as those of men is unreasonable.[9] In one study,[10] it was found that 80% of female physicians surveyed thought that having children had slowed their career progress. Although this information comes from the human medical field, much of it is applicable to female veterinarians.

In our survey, 67% of female veterinarians scored 3 or above on the burnout scale. This is the point at which clear-cut signs of the burnout syndrome occur. This 67% scoring above 3, with a mean burnout score of 3.41, compares with results of a nationwide survey of primarily male veterinarians in 1981, using the same burnout instrument, in which 53% scored above 3, with a mean burnout score of 3.09.[12]

Significant correlation was observed between higher burnout scores and veterinarians responding negatively to the following statements: I am happy in my current position; Women are treated equally to men in the veterinary profession; and If I had the choice to make again I would choose the veterinary profession. This result was expected because individuals feeling negatively about their profession would be expected to score higher on the burnout scale.

Women who worked over 40 hours per week and felt their jobs were stressful scored significantly higher burnout scores. This was also observed in the 1981 survey of male veterinarians.

An unexpected finding was significantly higher burnout scores in employed female veterinarians who were not involved in ownership of the practice. This leads one to think that the responsibility and problems associated with ownership and management of a practice do not add undo stress to the lives of female veterinarians. Likewise, being an employed veterinarian with no input into the business aspect of the practice and little control over her future leads to higher burnout scores.

A survey of this type has inherent problems with determining whether it is measuring burnout from occupational stress or burnout associated with personal factors. The high correlation of burnout scores with 87% of the respondents feeling their job was stressful suggest that the scale did, in fact measure work-related factors. Another factor to consider is that 397 women did not respond to the survey. Were the nonrespondents the most burned-out individuals, and so they failed to respond to the survey, or were they those successfully coping with stress and therefore believed responding was not necessary? Ideally a second and third contact with these nonrespondents should have been attempted, but was not done at this time.

What conclusions may be drawn from this survey? Female veterinarians did score higher on the burnout scale than did male veterinarians in a previous survey.[12] The reason for this was not determined, but assumptions can be made that personal and home responsibilities along with lower salaries contributed to this higher score. Eighty-three percent of the women were satisfied with being veterinarians and in their job position. This agrees with results of a recent study of female veterinarians in Texas in which 79% reported being happy in their veterinary career.[13] However, most of these women thought they were not treated equally to men in the profession. This is reflected in lower number of job offers to women and lower salaries than men.[14] For women practicing veterinary medicine, starting salary averaged $4,433 less than that of the men.[14]

Forty-two percent of the women were involved in ownership of their practices. Managing the practice and economic concerns were the most stressful factors reported. In another study, it was reported that women and men who graduated from veterinary school prior to 1970 experienced a higher degree of enjoyment from their practice than did those who graduated in the 1970s or 1980s.[13] In our survey, only 3.1% of the respondents graduated prior to 1970, so no conclusions could be drawn. Seventy-one percent said they would choose the veterinary profession again if they had that decision to make.

Women currently comprise over 50% of graduating veterinarians. Because of personal and family responsibilities, demands on female veterinarians are greater than those on male veterinarians and may require schedule adjustments. These factors should be considered and addressed during the professional educational process. Female role models and mentors should take an active role in counseling and advising students of successful coping strategies for the prevention of burnout. Although women in this survey did score higher than men in another survey, most were happy in the profession while working over 40 hours per week.

Appendix

Burnout self-diagnosis instrument
All Participants please complete the following self-diagnosis instrument. (You do not have to compute your score).

Veterinarians can compute their burnout score by completing the following questionnaire, using the following scale:

1 2 3 4 5 6 7
Never Once in a great while Rarely Sometimes Often Usually Always

How often do you have any of the following experiences?

_____ 1. Being tired.
_____ 2. Feeling depressed.
_____ 3. Having a good day.
_____ 4. Being physically exhausted.
_____ 5. Being emotionally exhausted.
_____ 6. Being happy.
_____ 7. Being "wiped out."
_____ 8. Feeling "burned out."
_____ 9. Being unhappy.
_____ 10. Feeling rundown.
_____ 11. Feeling trapped.
_____ 12. Feeling worthless.
_____ 13. Being weary.
_____ 14. Being troubled.
_____ 15. Feeling disillusioned and resentful about people.
_____ 16. Feeling weak.
_____ 17. Feeling hopeless.
_____ 18. Feeling rejected.
_____ 19. Feeling optimistic.
_____ 20. Feeling energetic.
_____ 21. Feeling anxious.

Computation of score:
Add the values you wrote next to the following items:
1,2,4,5,7,8,9,10,11,12,13,14,15,16,17,18,21 = ____(A).
Add the values you wrote next to the following items:3,6,19,20 = ____(B).
Subtract B from 32: 32 − B = ____(C).
Add A and C = ____(D).
Divide D by 21 = ____. This is your burnout score.

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Zoo veterinarians—doctors on the ark?

R. Eric Miller, DVM

In a corner of the Cincinnati Zoological and Botanical Gardens stands a small, restored pavilion. Its displays contain no living animals, but rather the preserved bodies of the last passenger pigeon and the last Carolina parakeet. Both died there during World War I, the last representatives of species driven to extinction by human interference outside of the zoo's boundaries. Next door, "living" exhibits feature Cincinnati's large breeding group of gorillas and a feline house specializing in small, endangered exotic cats. As wild habitats and animals become increasingly threatened, the juxtaposition of facilities is appropriate. Many of the more than 104,000,000 annual visitors to North American zoological institutions[a] fail to realize that numerous zoo "favorites", such as Siberian tigers *(Panthera tigris altaica)*, Asian elephants *(Elephas maximus)*, and orangutans *(Pongo pygmaeus)*, are endangered in the wild and are subjects of intensive captive breeding programs.[1] Yet other species, such as California condors *(Gymnogyps californianus)* and black- footed ferrets *(Mustela nigripes)*, have depended on captive breeding programs for their very survival.

As zoological parks remain centers for public entertainment and pleasure, via education, research, and breeding, they have also become conservation centers. In this role, fulfilling basic animal welfare needs lays the cornerstone for the ultimate animal welfare issue, that of preventing the extinction of species.

As medical personnel and as part of a larger team of zoo professionals, veterinarians have a key role in animal welfare at zoological institutions. As recently as 1982, Robert Bendiner wrote, "until the last decade, a resident veterinarian was the rarest animal to be found in the zoo."[2] Today, the situation has changed greatly, because nearly every major zoological facility has a full-time veterinarian. Many have staffs that include several clinical veterinarians along with nutritionists, pathologists, behavioralists, and reproductive researchers (Fig 1). Indeed, Dr. David Wildt, a reproductive researcher at the National Zoological Park, has suggested that advances in veterinary medicine (especially capture, restraint, anesthesia, and medical management) have had key roles in changing and expanding the direction of (zoo) research programs.[3]

Figure 1—Quarter Horse mare and newborn zebra delivered by the mare as a result of an embryo transfer procedure. Reprinted with permission from the Courier-Journal *May 17, 1984;A-12. Photograph by Paul Schuhmann.*

Veterinary concerns in animal welfare are wide-ranging. Historically, the identification and treatment of disease in individual animals and species in each institution were central to the veterinarian's role in animal welfare. Catastrophic epizootics of infectious disease, such as rhinotracheitis in clouded leopards *(Neofelis nebulosa)* and parvovirus in South American canids, reinforced

From the St Louis Zoological Park, 1 Government Drive, Forest Park, St Louis, MO 63110-1396.

[a]For this paper, the terms "zoological park (zoo)" and "aquarium" will refer to the 160 accredited members of the American Association of Zoological Parks and Aquariums. Nearly all major public and private zoological institutions are members.

the importance of these activities.[4,5] But zoo veterinarians' interest has expanded beyond diagnosis and treatment of individual animals, and includes the evaluation of populations and preventive medicine, a situation more similar to the orientation of wildlife veterinarians.[6]

In zoological institutions, prevention of disease is critical because the untamed nature of the patients makes intensive treatment of many species difficult if not impossible. Preventive medicine programs include vaccinations (eg, lions and tigers for feline respiratory viruses), parasite surveillance (monitoring gorillas for *Balantidium coli* or orangutans for *Strongyloides* sp), testing for tuberculosis and the communicable diseases, and routine quarantine of new arrivals to prevent introduction of disease into an established animal collection. Preventive medicine in zoological parks also includes identification of environmental factors that may make captive species more susceptible to opportunistic pathogens.[7]

Animal welfare in zoological institutions is regulated by several government agencies. The Animal Welfare Act, which covers animal food, housing, health and safety, is central to this regulation. Since 1970, its enforcement in zoological parks has been carried out by USDA inspections of the more than 1400 facilities that have a USDA license to exhibit animals.[8] The USDA provisions include exotic animals, but exclude birds, reptiles, amphibians, fish, and certain domestic and laboratory-bred mammals.[8,9] The Animal Welfare Act also regulates animal transport and its most recent amendment addresses the psychological well-being of primates.

Veterinarians are central to the inspection process at zoological institutions, both as inspectors and as supervisors. In fact, for the psychologic well-being of primates, the attending veterinarian at the institution is responsible for overseeing application of the Animal Welfare Act standards. Additionally, at institutions with active research programs, veterinarians are integral in the function of Institutional Animal Care and Use Committees. Besides the standards of the Animal Welfare Act, zoos and aquariums have other federal regulations to meet as well. They are subject to the Department of Commerce's Marine Mammal Protection Act of 1972, which specifies housing and water conditions for marine mammals, and the Interior Department's Endangered Species and Migratory Bird Acts that require permits for the maintenance of covered species.[10]

In 1980, the zoological community developed a second, rigorous system of regulation through the accreditation process of the American Association of Zoological Parks and Aquariums (AAZPA). By 1985, all AAZPA institutions had complied or lost membership. Today, 160 North American zoological institutions are accredited members of AAZPA.[1]

The scope of the AAZPA inspections is broader than that of the federal government, for example, all animal species are covered. In addition to food, water, and housing, further attention is given to the social needs of the animals, record keeping, research, and captive propagation of endangered species. By their Code of Ethics, zoos are bound to see that the animals in their care receive humane care. In addition, animals may only be transferred to other institutions that are capable of providing professional care, and if they are euthanatized, it must be done so humanely. The accreditation process also requires cooperation in local, national, and international conservation programs, and the provision of educational programs for the public. Member institutions must file detailed financial statements to demonstrate their ability to provide for the sustained care of the animals in their charge.

Table 1—Comparative rates of species extinctions

Time	Rate of extinction
70,000,000 years ago (disappearance of the dinosaurs)	1 species/1000 years
1 AD to 1650	1 species mammal or bird/82 years
1650 to 1850	1 species mammal or bird/5 years
1850 to 1900	1 species mammal or bird/9.5 months
1900 to 1950	1 species mammal or bird/8 months
Present	All plant and animal life, 1 to 6 species/day
2000 (projected)	All plant and animal life, 1 species/hour

These regulations reflect the concern of zoo professionals, governmental agencies, and the public in the humane and improved care of captive animals. Simply stated by Dr. Morton Silberman, "husbandry that promotes well-being is synonymous with humane treatment."[11] Nutritious feedstuffs, appropriate social groups, and adequate housing all seem obvious requirements. Yet, for animals in zoos, the provision of each is often the result of years of research. For example, many species have evolved complex and specialized feeding strategies, but often these are diets that zoos are still studying and refining.[12]

Increasing knowledge of animal behavior has advanced our concepts of animal welfare and housing.[13] "Postage stamp" exhibits that featured few individuals and large numbers of species have been replaced by more naturalistic displays featuring groups, troops, and other arrangements that parallel a species' natural social structure.[14] Gorillas are an example. They rarely reproduced in pairs, but have been much more fecund when placed in larger troops that mimic their wild society.

At a time when zoos are focusing on breeding endangered species, the preservation of species becomes the paramount animal welfare issue. Arguably, extinctions are part of the natural process of Darwinian evolution, but the current number of extinctions is compounded exponentially by man-made environmental changes and destruction (Table 1).[2,15,16] In this maelstrom of endangerment, zoos are a potential means of survival for some

critically endangered species. However, the numbers of endangered species are too overwhelming for zoological institutions to become "arks" for all species (it has been estimated that zoos could manage 2000 vertebrate species).[17]

Responsible zoo professionals readily acknowledge that the first priority is to maintain a species in its native, intact environment. Michael Hutchins, AAZPA Director of Conservation and Science observes, "captive propagation cannot be considered as a panacea for the endangered species problem and should be implemented as part of a more holistic effort to preserve species in their natural habitats."[18] But for many species, political instability (the kouprey, *Bos sauveli* in Cambodia); introduced predators (the Micronesian kingfisher on Guam); introduced disease (the gaur, *Bos gaurus*, in Southeast Asia); poaching for commercially valuable products (the black rhinoceros, *Diceros bicornis*, across sub-Saharan African); and most commonly, massive habitat destruction (all the prosimian primates on Madagascar) create a future threatened by the risk of unnatural extinction. For these and other species, captive breeding may serve as an alternative to extinction until current political and environmental instabilities resolve.[19]

Some captive-bred animals have already been returned to their native habitats. As early as 1907, American bison *(Bison bison)* from the New York Zoological Society were used to reestablish several bison herds in the American West.[20] Today, golden lion tamarins *(Leontopithecus rosalia)* are being reintroduced into Brazilian rain forests, and after being hunted to extinction in the 1960s, captive-bred Arabian oryx *(Oryx leucoryx)* from the San Diego and Phoenix Zoos have returned to Jordan and Oman. But for many captive-bred species, reintroduction remains a distant goal because of continued habitat destruction or political instability in their native areas.[19]

The success of captive breeding programs should not be based solely on reintroductions. Many intensive genetic and nutritional analyses, telemetry trials, and behavioral and disease studies are more readily performed in zoological parks because of the greater accessibility of captive animals. Almost invariably, research in zoos focuses on projects that benefit the animals and their species, producing results that are often applicable to the conservation of captive as well as wild individuals still afield. The scope of zoo-based research is growing; a recent survey reported 388 conservation research projects in zoos of 63 countries.[21] From 1990 to 1991, more than 400 technical articles on wildlife biology and conservation research were published in North America by AAZPA institutions.

Vital to the maintenance of endangered species in captivity is the development of programs that preserve their genetic variability over the long term. The clear challenge is to preserve an animal most like its wild relatives in appearance, fertility, resistance to disease; a product of natural selection, not an artificial subspecies produced by the selection of man. Although 90% of the mammals currently exhibited in North American zoos are captive born,[19] the Asian wild horse *(Equus przewalskii)*, the last truly wild (not feral) horse, illustrates the inbreeding predicament. Bred from captive stock since the turn of the century, in the intervening decades, the head shape of the animals has changed. Thus we question whether we have saved the Asian wild horse, or a semi-domesticated version of it.

To avoid this dilemma, a definition of what constitutes saving a species is necessary. Genetic modeling provides us with one definition, saving a species requires the maintenance of 90% of its genetic variability over the next 200 years or 50 generations.[17] To achieve that goal, on the basis of mathematical models, 250 breeding animals would be needed for most species (for some slower breeding species [eg, Asian elephants], 50 might be enough, for some faster breeding species [eg, elephant shrews], 1000 or more might be required).[17] Because only a relative few individuals of each species are housed in each zoo, cooperation without coordination is insufficient to preserve wild animals in captivity over long periods of time.[19,22]

In North America, coordination has been provided by the Species Survival Plans (SSP) of the AAZPA. Currently the management of more than 60 threatened species is done by a committee (Appendix). The AAZPA has set a goal of 200 SSP committees by the year 2000. Similar programs have been organized in Europe, Japan, Australia/New Zealand, Brazil, Southeast Asia, and Africa. The Captive Breeding Specialist Group, a more than 300-member international committee of the World Conservation Union, oversees the global coordination of these regional programs. Worldwide, animals may be identified and located through another organization, the International Species Information System.

Perhaps the Siberian tiger *(Panthera tigris altaica)* best illustrates the function of a SSP. Today more Siberian tigers live in zoos (600 to 700) than in the wild (estimated 300 to 400). Yet, all of the world's captive Siberian tigers descend from 44 "founder" tigers (wild individuals that were presumably unrelated). In Siberian tigers, as in many species, the founders are not equally represented; some have had more breeding success than others.[19] The St. Louis Zoological Park's Siberian tigers were genetically over-represented and the tiger SSP determined that they should not be bred (a progesterone implant was placed in the female). When space became available, new, genetically underrepresented lineages were located (a male tiger from San Diego and a female tiger from the Denver Zoo) and placed together at St. Louis. The match was a success in that breeding took place and 2

cubs resulted (whose future placement will be at the direction of the SSP).

However, problems quickly arise. Space limitations are illustrated by the 1750 spaces for large cats in North American zoos, which is space for SSP programs for 7 species if we accept the assumption of a necessary 250 breeding individuals/species (in reality, such a number usually requires a population at least twice that size).[23] Thus, zoos must select 7 species of large cats in which to invest their finite resources (all the world's zoos would fit within an area the size of Washington, DC).[19,24]

This selection requires wisdom. A form of conservation triage exists, a protocol for selecting species for captive breeding.[25] Priority is given to animals that may be in immediate danger of extinction or that may represent the last living member of genus or taxonomic family. If there is not a reasonable chance of success for captive breeding (eg, has the maintenance of related, nonendangered species been successful?), priority is reduced.

The medical management of these small, captive populations offers unique opportunities for veterinarians. The deleterious effects of inbreeding include the potential for altered resistance to disease.[26] According to Dr. Linda Munson, a veterinary pathologist, diseases could prove to be greater modifiers of small populations in the future than the past because of greater habitat and genetic restrictions.[27]

In part, Dr. Munson's observation is illustrated by the prevalence and high morbidity of feline infectious peritonitis in cheetahs.[28] It is a situation likely compounded by their genetic impoverishment.[26] It is a disease, like several others, that markedly complicates the movement of animals between institutions for genetic purposes. The cheetah SSP Committee has been a leader in the interdisciplinary approach to solving these problems. Its research advisory group contains a nutritionist, geneticist, clinical veterinarian, veterinary pathologist, reproductive physiologist, and behavioralist.

As advisors to SSP and related committees, veterinarians are in a central position to monitor vital statistics and disease trends that affect the growth and survival of a captive population. Their role includes the cataloguing of each species' diseases, establishment of preventive medicine programs, and determining veterinary research needs.

Of vital importance to the future maintenance of genetic diversity is research into the reproduction of endangered species.[29-32] With reproductive physiologists and many others, veterinarians have had an active role in the development of cycle determination, artificial insemination, and embryo transfer, which are steps that will aid in the transfer of genetic material between zoos (and the first step in transferring genetic material from the wild to captivity and vice versa or between parks).

Even at necropsy, SSP veterinarians attempt to establish disease patterns and collect tissues for comparative studies vital to the survival of many endangered species.[27] Species Survival plan veterinarians are one source for central tissue/sera repositories vital for future research. And the demand for veterinary participation is a growing one; one estimate suggests a need for 240 veterinary advisors to SSP and related committees by the year 2000 (presently, there are approximately 100 full-time zoo veterinarians).[6]

As members of some captive populations are being prepared for return to the wild, close attention must be paid to the potential for disease spread (the same is true when wild animals are brought into captivity, or if wild animals are translocated between habitats). As golden lion tamarins are being prepared for reintroduction into the coastal rain forests of Brazil, the problems of infectious diseases and genetic defects (eg, coronaviral hepatitis and diaphragmatic hernias) take on critical importance.[33,34] The issues may be more mundane, but no less important (eg, it is critical that Arabian oryx returning to the Middle East be free of tuberculosis or viral diseases such as bluetongue that reside in the United States). Evaluating such risks is vital to the future success of reintroduction programs. In recognition of this, the Captive Breeding Specialist Group is organizing a seminar that will address these issues (November 1992, Oakland, Calif.).

As wildlife habitats continue to shrink, zoological institutions are extending their view beyond those endangered animals that they maintain within their perimeters. An enviable record of funding field programs (more than $4,000,000 annually[21]) has been achieved by Wildlife Conservation International, a division of the New York Zoological Society. It is being joined by a growing cadre of zoos funding habitat protection and field research (eg, the San Diego Zoo's support for the Darwin Research Station in Ecuador helps breed endangered subspecies of the Galapagos tortoise *[Geochelone elephantopus]*, the Minnesota Zoo's "adoption" of Ujon Kulong National Park in Indonesia protects a reserve that is home to the largest remaining population of Javan rhinoceroses *[Rhinoceros sondaicus]*). In such ways, zoological parks can offer unique opportunities for locally supported institutions to contribute to global conservation.[24]

In a similar manner, zoo veterinarians have a growing role in international conservation. In a forward-looking program, the New York Zoological Society employs a full-time veterinarian to service its field projects. Additionally, Dr. Christen Wemmer has established a zoo school that employs a team of zoo professionals to disseminate zoo management and conservation biology techniques to zoological parks in the underdeveloped world.[35] Zoo veterinarians have been active participants in that program and in Zoo Conservation Outreach

Group, a cooperative organization of 32 North American zoological parks and 15 Central American zoos.

As the wild grows smaller, and zoological institutions expand their horizons, the line between captivity and the wild is often blurred. The plight of black rhinoceroses in their native Africa illustrates the point. After a 90% decrease in black rhinoceros numbers (primarily attributable to poaching), the Kenyan government designed a successful sanctuary program that translocated animals from vast, poorly protected parks to smaller, fenced parks and ranches, areas more readily monitored and defended. In the sanctuaries at Lake Nakuru, Solio Ranch, and elsewhere, black rhinoceros numbers have been growing, but only in areas that have carrying capacities between 15 and 100 animals. The situation is similar for elephants, "the distribution of human and elephant populations has changed from one characterized by human islands in a sea of elephants to increasingly small islands of elephants in a sea of people."[36] In reality, the protective fencing for the rhinoceroses or the isolation created by a sea of people has created "megazoos," complete with the specter of inbreeding. Moving rhinoceroses from zoo to zoo is a large enough task in itself; moving them from sanctuary to sanctuary is even more herculean. Thus the genetic management and reproductive studies in zoological institutions have impact on these populations as well,[37] and new opportunities are presented for the zoological and wildlife communities to share interests on common ground.

Through continued research, health monitoring, animal movement and the prevention of disease, veterinarians have vital roles in the preservation of endangered species. Captive propagation programs provide hope to some of the threatened species alive in a world rife with environmental danger. The sheer scale of the present ecological crisis precludes zoological institutions from becoming "arks" to all endangered species, but through careful selection and design, they can be "lifeboats" for many.

Captive propagation cannot be an end unto itself, but rather an integral part of the larger mosaic that is education, research, and field conservation. All seek preservation. To prevent losses of animal species should be the ultimate goal in animal welfare, for the species involved and for ourselves.

Appendix

Species presently included in species survival plans of the American Association of Zoological Parks and Aquariums

MAMMALS

addax (*Addax nasoma culatus*)
African elephant (*Loxodonta africana*)
Arabian oryx (*Oryx leucoryx*)
Asian elephant (*Elephas maximus*)
Asian lion (*Panthera leo persica*)
Asian small-clawed otter (*Aonyx cinerea*)
Asian wild horse (*Equus przewalskii*)
Baird's tapir (*Tapiris bairdii*)
barasingha deer (*Cervus duvauceli*)
black-footed ferret (*Mustela nigripes*)
black lemur (*Lemur macaco*)
black rhinoceros (*Diceros bicornis*)
bonobo (pigmy chimpanzee—*Pan paniscus*)
Chacoan peccary (*Tayassu wagneri*)
cheetah (*Acinonyx jubatus*)
chimpanzee (*Pan troglodytes*)
clouded leopard (*Neofelis nebulosa*)
drill baboon (*Papio leucophaeus*)
gaur (*Bos gaurus*)
gibbons (*Hylobates* sp)
golden lion tamarin (*Leontopithecus rosalia*)
greater one-horned rhinoceros (*Rhinoceros unicornis*)
Grevys' zebra (*Equus grevyi*)
lion-tailed macaque (*Macaca silenus*)
lowland gorilla (*Gorilla gorilla*)
lowland tapir (*Tapiris terrestrus*)
Malayan tapir (*Tapiris indicus*)
maned wolf (*Chrysosyon brachyurus*)
okapi (*Okapia johnstoni*)
orangutan (*Pongo pygmaeus*)
red panda (*Ailurus fulgens*)
red wolf (*Canis rufus*)
ruffed lemurs (*Lemur variegatus*)
scimitar-horned oryx (*Oryx tao*)
snow leopard (*Panthera uncia*)
spectacled bear (*Tremarctos ornatus*)
Sumatran rhinoceros (*Didermocerus sumatrensis*)
tiger (*Panthera tigris* sp)
white rhinoceros (*Ceratotherium simum*)

BIRDS

Andean condor (*Vultur gryphus*)
Bali mynah (*Leucospar rothschildi*)
California condor (*Gymnogyps californianus*)
Guam rail (*Rallus owentoni*)
hooded crane (*Grus monacha*)
Humboldt penguin (*Spheniscus humboldti*)
Micronesian kingfisher (*Halcyon c cinnamomina*)
palm cockatoo (*Probosciger atterimus*)
red-crowned crane (*Grus japonensis*)
St. Vincent parrot (*Amazonia guildingii*)
thick-billed parrot (*Rhynchopsitta p pachyrhyncha*)
wattled crane (*Bugeranus carunculatus*)
white-naped crane (*Grus vipio*)

REPTILES AND AMPHIBIANS

Aruba Island rattlesnake (*Crotalus unicolor*)
Chinese alligator (*Alligator sinensis*)
Dumeril's ground boa (*Acrantophis dumerili*)
Puerto Rican crested toad (*Peltophryne lemur*)
radiated tortoise (*Geochelone radiata*)
Virgin Island boa (*Epicrates monensis*)

FISH

Lake Victoria cichlids (*Haplochromus* sp and others)

INVERTEBRATES

Partula snails (*Partula* sp)

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